

Congenital Cytomegalovirus and
Sensorineural Hearing Loss (SNHL)

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Sciences

- Cytomegalovirus (CMV) is a member of the herpes virus family and is spread from person to person through exchange of infected bodily fluids; it can be acquired at any point during a person's lifetime.
- Acquired CMV, which is acquired anytime after birth, does not produce any associated sequelae or disabilities.
- Congenital CMV, which is acquired at any time during the fetal period, can result in serious, permanent disabilities, including neurological, cognitive, motor, visual, and auditory impairments (Dollard, Grosse, & Ross, 2007).

- Infants with congenital CMV that have one or more associated sequelae present at birth are symptomatic, while infants that test positive for CMV at birth but do not have any associated sequelae are asymptomatic.

Prevalence:

- Prevalence of congenital CMV is generally reported to be between 0.5-2.5%
- Congenital CMV is the most common cause of non-genetic SNHL in children, accounting for 2-18% of all children who are deaf. (The range is due to the difficulty of diagnosing asymptomatic congenital CMV in children with SNHL, especially if it is a late-onset SNHL, which will be discussed later).
- Currently, congenital CMV is the only virus that is a substantial cause of SNHL in children (in developed countries), since rubella, measles, and mumps have been almost eradicated by vaccinations (Barbi, Binda, Caroppo, Ambrosetti, Corbetta, & Sergi, 2003).

This webpage will explore various aspects of symptomatic and asymptomatic congenital CMV, including: associated sequelae, characteristics of SNHL, neurodevelopmental and cognitive outcomes, audiological management, amplification, educational outcomes, and implications for newborn hearing screening, aural rehabilitation therapy and language outcomes.

Symptomatic CMV

Medical Characteristics of Symptomatic CMV

- Of the infants who tested positive for congenital CMV from a universal screening, 12.7% were symptomatic at birth (Dollard et al., 2007).

- In order for infants to be considered symptomatic, they must have one or more of the following symptoms at birth: petechiae (small, purplish hemorrhages on the skin or mucous membranes), hepatosplenomegaly (enlarged liver and spleen), hyperbilirubinemia, chorioretinitis (inflammation of the retina and choroid), thrombocytopenia (abnormal decreased number of blood platelets), seizures, microcephaly (abnormally small head), intracranial calcifications, or fetal hydrops (abnormal accumulation of blood serum) (Dollard et al., 2007).
- Infants with symptomatic congenital CMV exhibit the following prevalence of sequelae:
 - petechiae (45-79%),
 - hepatosplenomegaly (24-74%),
 - hyperbilirubinemia (28-63%),
 - microcephaly (15-70%),
 - chorioretinitis (6-17.1%),
 - thrombocytopenia (50-68.3%),
 - intracranial calcifications (50-58.5%) and
 - seizures (19-29%).
 - The prevalence of fetal hydrops was not reported (Kylat, Kelly, & Ford-Jones, 2006; Madden, Wiley, Schleiss, Benton, Meinen-Derr, Grienwald, et al., 2005; Noyola, Demmler, Nelson, Griesser, Williamson, Atkins, et al., 2001; Pass et al., 1980; and Schildroth, 1994).

Note: Prevalence figures for various sequelae and outcomes will often be reported as a range in this paper due to the variability reported in the studies cited. Unless otherwise

noted, the reason for the range is due to the small sample sizes and variability in the samples studied at each research center. For example, research centers that rely mostly on referrals from other clinics are most likely to have the most severely affected children in their samples, while other centers follow children identified through universal screening for CMV and therefore are more representative of the general population.

- Permanent sequelae were present in 40-58% of the infants with symptomatic congenital CMV (Dollard et al., 2007).
- Mortality rate ranged between 5-10% (Dollard et al., 2007) and 30% (Pass et al., 1980; and Schildroth, 1994).
- Since the 5-10% mortality rate was found in samples diagnosed with universal screening, it is likely more representative of the general population, while the 30% mortality rate is likely representative of the most severely affected infants,
- Pass et al. (1980) had a number of referrals to their research center
- Schildroth (1994) used data from Gallaudet University's Center for Assessment and Demographic Studies (CADS) survey
- The CADS survey is given primarily to special education programs and schools for the deaf and therefore, only describes children with severe-to-profound SNHL
- Several other sequelae are commonly associated with CMV, but cannot be used to diagnose symptomatic congenital CMV, including prematurity, intrauterine growth retardation (IUGR), cerebral palsy, SNHL, and other neurological deficits.

The following prevalence of these sequelae has been observed:

- Prematurity (21-34%),
- IUGR (Intrauterine Growth Restriction (26.8-43%),
- Cerebral palsy (13-33%),
- SNHL (30-57.8%) and
- SNHL, neurological deficits, or both (90-93%) (Kylat et al., 2006; Madden et al., 2005; Noyola et al., 2001; Pass et al., 1980; and Schildroth, 1994).

Symptomatic CMV and SNHL

- SNHL is the most common symptom in children with symptomatic congenital CMV, with a prevalence ranging from 30-57.8% (Fowler & Boppana, 2006; Kylat et al., 2006; Noyola et al., 2001; and Pass et al., 1980).
- CMV is thought to cause SNHL by invading the inner ear and spiral ganglion cells.
- Post-mortem temporal bone studies of children that died from symptomatic congenital CMV have found CMV infection present in Reissner's membrane, the stria vascularis, the scala media, spiral ganglion cells, and the organ of corti. Damage to the central auditory pathways from sequelae associated with CMV, such as microcephaly or cerebral palsy, may also cause SNHL (Madden et al., 2005).

- Studies have examined whether the presence of specific sequelae at birth in children with symptomatic congenital CMV were a predictive risk factor for development of SNHL.
- Widespread sequelae at birth was the best predictor of SNHL, specifically petechiae, hepatosplenomegaly, thrombocytopenia, hepatitis, and IUGR.
- Infants with increased levels of CMV in urine samples were also at a higher risk of developing SNHL, likely because a higher level of CMV in urine is associated with greater viral burden and development of sequelae.
- Only petechiae could independently predict SNHL. Infants with petechiae were three times more likely to develop SNHL than infants without petechiae. CNS impairment was not a predictive risk factor for developing SNHL (Fowler & Boppana, 2006; and Rivera, Boppana, Fowler, Britt, Stagno, & Pass, 2002).

Characteristics of Sensori Neural Hearing Loss:

- The characteristics of SNHL (time of onset, progression, severity, and audiometric configuration) are widely variable in children with symptomatic congenital CMV.
- SNHL can be present at birth (41.5-68.2%) or have a delayed onset (30-33%).
- The median age for delayed onset SNHL is 33 months (Fowler & Boppana, 2006; Kylat et al., 2006; and Rivera et al., 2002).
- Hearing thresholds can be:
 - stable (52%),
 - progressive (38-63%),

- fluctuating (5%), or
- progressive and fluctuating (5%).
 - Progressive SNHL occurred over a median of 60.5 months (range 35-118 months) (Madden et al., 2005; Rivera et al., 2002). In the Madden et al. (2005) study, which retrospectively reviewed the data of 21 children with symptomatic congenital CMV identified from a database of children with hearing impairments,
 - the median initial pure tone average (PTA) was better for the children with a progressive hearing loss (66 dBHL) compared to the children with a stable hearing loss (104 dBHL).
 - The severity of the initial PTA was a significant predictor for the development of progressive hearing loss.
 - One explanation the authors offer is that CMV-related SNHL is progressive by nature in children with symptomatic congenital CMV,
 - but is more apparent in the children with milder initial PTAs because there is more testable hearing, so the deterioration of hearing thresholds is more obvious.
 - However, further research would need to verify this, since some children do not have severe to profound SNHL and never develop progressive SNHL.

- Children with symptomatic congenital CMV presented with either unilateral (24-42.9%) or bilateral (57-76%) SNHL (Madden et al., 2005; Pass et al., 1980).
- The severity of SNHL ranged from mild to profound.
- The median PTA at birth was 77 dBHL (ranging from 20-130 dBHL) and
- the last known PTA was 99 dBHL (ranging from 35-130 dBHL) in the Madden et al. (2005) study.
- Of the data given for eight children with a unilateral SNHL from Madden et al. (2005) and Pass et al. (1980),
 - 12.5% had a mild fluctuating loss,
 - 25% had a stable moderate loss,
 - 25% had a stable moderately severe loss,
 - 12.5% had a moderate loss that progressed to severe, and
 - 25% had a stable profound loss. Madden et al. (2005),
- Pass et al. (1980) and Schildroth (1994) reported the severity of loss in children with a bilateral SNHL. The following prevalence of hearing loss severity were observed:
 - normal hearing (0-2%),
 - mild loss (1-6.3%), moderate loss (4-18.8%),
 - moderately severe loss (5%),
 - severe loss (6.3-17%),
 - profound loss (68.7-100%) (Fowler & Boppana, 2006; Madden et al., 2005; Pass et al., 1980; and Schildroth, 1994)

- Madden et al. (2005) was the only study to report the prevalence of audiometric configurations;
 - 48% were sloping,
 - The sloping configuration was significantly associated with progressive hearing loss
 - 17% were flat,
 - while the flat configuration was significantly associated with microcephaly, which suggests damage to the central auditory pathways.
 - 5% were a rising cookie-bite.

Neurodevelopmental and Cognitive Outcome

Cognitive Development:

- Kylat et al. (2006), Noyola et al. (2001), and Pass et al. (1980) longitudinally followed children with symptomatic congenital CMV until a median age of 4-5.7 years (ranging from 9 months to 14 years) to determine neurodevelopmental and cognitive outcomes.
 - Age-appropriate intellectual assessments were administered, including the Bayley Scales of Infant Development, McCarthy Scales of Children's Abilities, Stanford-Binet Intelligence Scale, Wechsler Intelligence Scale for Children-Revised, Leiter

International Performance Scale, and the Kaufman Assessment Battery for Children.

- A cognitive or developmental delay was present in 61-86% of all children longitudinally followed.
- Based on the most current neurodevelopmental assessment given at follow-up for Noyola et al. (2001),
 - 29.2% of the children with symptomatic congenital CMV had normal intelligence (IQ/DQ \geq 90),
 - 24.3% had an IQ/DQ ranging from 70-89,
 - 9.7% had mental retardation (IQ/DQ ranging from 50-69), and
 - 36.5% had severe mental retardation (IQ/DQ < 50).
 - In the Pass et al. (1980) study,
 - 4% of the children with symptomatic congenital CMV had an IQ/DQ between 50-80,
 - 39% of the children had an IQ/DQ below 50, and
 - 17% of the children had not yet received an intellectual assessment but had a psychomotor delay.
 - Absence of central nervous system (CNS) involvement did not predict cognitive function;
 - about 50% of the children without CNS involvement had an IQ/DQ below 50.

Motor Development:

- In addition to cognitive and developmental delays, a significant number of the children with symptomatic congenital CMV had motor delays
 - (25% mild,
 - 31% moderate,
 - 26-36.5% severe).
 - Microcephaly was a predictor of severe motor delay, which is defined as the presence of motor impairment(s) that inhibited the ability of the child to perform tasks necessary for daily living.
 - Every child that had a major motor disorder had an IQ/DQ < 70 (Kylat et al., 2006; and Noyola et al., 2001).
 - Noyola et al. (2001) found no association between cognitive outcome and congenital SNHL.
 - However, children with symptomatic congenital CMV that had late-onset SNHL detected at a follow-up visit had a lower IQ/DQ (mean = 65.3) than children with symptomatic congenital CMV with normal hearing (mean = 88.7).
 - Additionally, of all children with symptomatic congenital CMV, children with SNHL were more likely to have a major motor disability (50%) than children with normal hearing (7.7%).

- The authors suggest that the lower IQ/DQ and greater likelihood of having a major motor disability are due to CNS abnormalities, since children with SNHL were more likely to have an abnormality detected by CT scan.
- However, this does not explain why children with symptomatic congenital CMV that have SNHL at birth do not differ in cognitive outcome from those with normal hearing.
- Additionally, this study does not explore whether the lower IQ/DQ scores in the children with SNHL identified at a follow-up visit are the result of a cognitive impairment or late detection of the SNHL. Further research should explore these questions and see if the results can be replicated, since the results are based on only one study.
- Since the absence of CNS involvement was not predictive of cognitive function and about half of children without CNS involvement have intellectual impairment, it is important to have every child with symptomatic congenital CMV given cognitive assessments, regardless of whether any neurological deficits are present (Pass et al., 1980).
- Additionally, the Pass et al. (1980) study found that all children with an IQ below 50 or a psychomotor delay were

apparent by age 1, even though the outcome severity could not be predicted based on symptoms at birth.

- Future research should further examine this finding to see if it can be replicated, since only one study found these results, parents should be advised that their child should be closely monitored in all aspects of development throughout at least the first year of life so that development of any cognitive, neuromuscular, or visual impairments can be detected as soon as possible.
- Early detection and intervention with proper therapy will help maximize the child's outcome.
- Kylat et al. (2006) recommends long-term follow-up at least up to school age because some neurological deficits may improve with time and other neurological or cognitive problems may not surface until the child is older.
- Neurological deficits that could improve were not described in this study; however, development of a learning disability when the child was older was mentioned. Based on these results, parents should be counseled that the child's educational needs may change with time, and that close monitoring in all areas will help determine the need for change as soon as possible.

- Additionally, future research should follow children through a later age to see if development of neurological deficits and learning disabilities continues past school age.

Audiological management

- Since a large percentage of children with symptomatic congenital CMV have late-onset (30-33%) or progressive SNHL (38-63%), the need for regular audiological evaluations is critical.
- Since it is currently not possible to predict which children will develop SNHL based on sequelae, every child with symptomatic congenital CMV should have regular audiological follow-ups.
- Late-onset SNHL has been observed at a median of 33 months and progressive SNHL has been observed in children with symptomatic congenital CMV as late as 118 months (almost 10 years old) (Fowler & Boppana, 2006; Kylat et al., 2006; Madden et al., 2005; and Rivera et al., 2002).
- Based on these data, regular audiological evaluations should be completed every six months to a year at least through the age of ten on every child with symptomatic congenital CMV to ensure that if the child develops late-onset or progressive SNHL, it will be detected as soon as possible.

- With early detection of SNHL, proper amplification and aural rehabilitation therapy can be started as soon as possible in order to minimize delays in language or auditory skill development.
- Since a significant number of children have cognitive, motor, or visual impairments, it is important to take a detailed case history that includes all of these areas.
- The behavioral test should be appropriate for the child's developmental age (to account for cognitive impairment), and may need to be altered further if the child has any motor or visual impairments. For example, TROCA may need to be used instead of VRA if the child has visual impairments or the child has seizures.
- If the child has a motor delay, the test should minimize the amount of movement needed to respond, such as watching for eye movement during VRA instead of a head turn. The audiologist could also ask the parents what types of movement the child is capable of and use these for a response.
 - For example, if the child knows some sign language, he/she could sign a response.
 - Additionally, ABR may be used in situations where it is difficult to behaviorally test the child or to verify the behavioral thresholds obtained.

Amplification outcomes

- Few studies have reported the prevalence of amplification use in children with symptomatic congenital CMV with SNHL.
- In studies by Kylat et al. (2003) and Madden et al. (2005),
 - the prevalence of hearing aid use was 73%,
 - 5-9.1% used a cochlear implant after not obtaining benefit from hearing aids, and
 - the remaining 19% were observed for progression of SNHL but did not wear any amplification.
- Madden et al. (2005) also reported usage of FM systems in the classroom;
 - 24% of the children with SNHL that used hearing aids also used an FM system and
 - 5% used an FM system without hearing aids.
 - Three of the five children that were observed or only used an FM system had a unilateral hearing loss; two of them used oral communication.
 - The other two children that were observed had CNS involvement and used total communication, the severity of their SNHL was not mentioned.
 - These authors reported the prevalence of amplification use; benefit obtained from each type of amplification was not examined.

- Future research should examine hearing aid and FM outcomes in children with symptomatic congenital CMV so that it can be used as a counseling tool for parents to make an informed decision about what type of amplification may be best for their child's type of SNHL based on other factors, such as sequelae and presence of cognitive or motor delays.
- Since about 50% of children with symptomatic congenital CMV have an IQ/DQ below 70 (Noyola et al., 2001), the effectiveness of cochlear implants in children with CMV-related deafness has been debated.
 - Cochlear implant outcomes in children with congenital CMV have been studied; however, both studies fail to separately analyze the symptomatic and asymptomatic groups. The sample consists of both groups because the authors mentioned that some were born with sequelae while others were not. Additionally, the age of diagnosis of SNHL (0-2 years) and age at implantation (1.2-12.1 years) vary widely.
 - Therefore, the cochlear implant outcomes are presented for all children with congenital CMV-related deafness (Lee, Lustig, Sampson, Chinnici, & Niparko, 2005). Lee et al. (2005) retrospectively examined cochlear implant outcomes in children with congenital CMV that received a cochlear implant after receiving no benefit from hearing aids.

- Every child had received one hour per week of aural rehabilitation therapy for at least one year prior to follow-up for the study.
- Speech reception scores (SRS) were measured using appropriate tests for the age and speech development of the child, including the WIPI, PBK-word, PBK-phoneme, NuChips, GASP-word, GASP-sentences, LNT-word, LNT-phoneme, MLNT-phoneme, and HINT-quiet.
- Of the children with CMV-related deafness,
 - 23% had a progressive SNHL and
 - 77% were congenitally deaf.
 - All of the children with a progressive SNHL were able to achieve open set word recognition.
 - Of all the children with CMV-related deafness,
 - 64% were able to achieve open-set word recognition and
 - 73% were able to achieve closed-set word recognition.
 - In general, children without any cognitive or motor delays achieved better word recognition scores.
 - However, 2 children with cognitive and motor delays were able to achieve open set word recognition.

- Every child with CMV-related deafness showed some improvement in speech reception post-implantation. There was no significant relationship between the duration of deafness and age of implantation in predicting the SRS.

Speech Intelligibility:

- Additionally, Inscoe & Nikolopoulos (2004) examined the intelligibility of speech production and speech perception abilities of children with CMV-related deafness at various stages after implantation compared to children that were deaf but did not have CMV.
- The authors did not specify whether the SNHL was congenital, late-onset, or progressive, or how much aural rehabilitation therapy the children received.
- The Speech Intelligibility Rating scale was used to describe the children's speech production, and
- the Iowa Sentence Test was used to describe speech perception.
- The children with CMV exhibited a wide range of speech intelligibility; about half performed worse than the children whose deafness was not CMV-related, the other half performed as well or better.
- About 81% of the children with CMV-related deafness had as good or better speech perception than the children who were deaf without CMV.
- Results from Lee et al. (2005) and Inscoe & Nikolopoulos (2004) indicate that children with congenital CMV are likely to receive benefit from a

cochlear implant when combined with aural rehabilitation therapy, regardless of whether a cognitive or motor delay is present.

- Children with CMV-related deafness with normal cognition should be expected to perform the same as children that have non-CMV-related deafness.
- Children with a cognitive impairment can still see improvement in speech production and perception compared to pre-implantation.
- These results can be a useful counseling tool for parents to provide them with information if they are considering an implant for their child.
- Lee et al. (2005) found that a large number of children with CMV-related deafness were able to achieve open-set word recognition (64%) or closed-set word recognition (73%).
 - They do not examine whether there is a difference in performance of the children with progressive SNHL compared to those that were congenitally deaf.
 - Since the children with progressive SNHL have more auditory access prior to cochlear implantation since they have some period of hearing and exposure to language, these children could have a better outcome with cochlear implantation than children that are congenitally deaf.
 - Since a few children did not receive any benefit from a cochlear implant, future research should examine if there are any predictive factors for a positive versus negative cochlear implant outcome.

- While current studies have shown that a cochlear implant is a viable option for children with CMV-related deafness, answers to these questions will further aid in parental decision-making.

Ganciclovir therapy

- Ganciclovir is an intravenous antiviral drug that has shown some promise in treating SNHL in children with symptomatic congenital CMV that have CNS involvement.
- At least two studies have reported the prevention of hearing loss progression or improvement of hearing thresholds for at least one year post-ganciclovir treatment.
- Kimberlin, Lin, Sanchez, Demmler, Dankner, & Shelton et al. (2003) randomly assigned infants with symptomatic congenital CMV that had CNS involvement to receive six weeks of ganciclovir treatment (beginning in the first month of life) or to a control group.
 - A baseline ABR threshold obtained prior to treatment was compared to follow-up ABR thresholds at six months and one year.
 - The prevalence of progressive hearing loss in infants treated with ganciclovir was significantly less at the six month and one year follow-ups (0% and 21%, respectively) compared to the control group (41% and 68%, respectively).
- Another study by Michaels, Greenberg, Sabo, and Wald (2003) treated nine infants with symptomatic congenital CMV with CNS involvement with ganciclovir for a year and completed follow-up audiological evaluations (ABR or

- behavioral testing). At the last follow-up (median 2 years post-treatment, range 1-7 years), no child had progression of SNHL.
- The Kimberlin et al. (2003) and Michaels et al. (2003) studies also report children with symptomatic congenital CMV that have improvement in hearing thresholds post-ganciclovir treatment.
 - However, evidence that ganciclovir is the reason for improved thresholds is not as strong as it is for delaying or avoiding progression of SNHL.
 - In the Kimberlin et al. (2003) study, roughly the same percentage of children who received ganciclovir treatment (24%) had improvement in hearing thresholds at six months, compared to 29% of the control group.
 - The mean dB improvement in hearing thresholds was not significantly different either (>20 dBHL for the treatment group and 25 dBHL for the control group).
 - The mean was >20 dBHL for the treatment group because the baseline threshold for some of the patients was >90 dBHL, and the follow-up threshold was 70 dBHL.
 - However, at the one-year follow-up, 17% of the children that received ganciclovir had improved hearing thresholds compared to 0% of the control group.

- In the Michaels et al. (2003) study, 22% of the children had an improvement in hearing thresholds post-ganciclovir treatment. However, there was no control group, so it is difficult to attribute the improvement of hearing thresholds to the ganciclovir treatment.
- While ganciclovir therapy has been shown to provide benefit for at least six months and possibly a year post-treatment in delaying or preventing progression of SNHL in children with symptomatic congenital CMV that have CNS involvement, it is not without risks and difficulties.
- Since ganciclovir can be toxic, infants must stay in the hospital for the entire duration of treatment, placing substantial burden on the families.
- Additionally, the toxicity can have long-lasting consequences. The infant is at risk of acquiring neutropenia (decrease in white blood cells) and ganciclovir can be carcinogenic or toxic to the gonads.
- Parents should be thoroughly counseled about the benefits of ganciclovir therapy in preserving hearing and the potential risks and burden so that they can weigh the benefits and consequences before deciding to treat their child.
- The audiologic implications for delaying or preventing progression of SNHL or improving hearing thresholds are tremendous.
- While it is unknown at this time whether ganciclovir treatment can prevent the progression of SNHL beyond a year of age, preserving the child's hearing for even the first few months of life greatly benefits the child's language and auditory skill development.

- The more hearing a child has, the more access to auditory stimuli he/she will have, which will maximize language and auditory skill development.
- Ganciclovir therapy to delay the progression of SNHL or improve hearing thresholds in children with symptomatic congenital CMV with CNS involvement has shown some positive results in a few studies.
- However, there is still no antiviral treatment for children with symptomatic congenital CMV that do not have CNS involvement; therefore, these children cannot avoid progressive SNHL at this time.
- Further research needs to explore several factors before ganciclovir therapy is more widely recommended as a treatment.
- These studies had a number of children lost to follow-up due to the lengthy time commitment of the study; it is unknown whether these children exhibited similar results.
- Currently, the long-term effects of toxicity are being examined to determine whether there are serious risks that would contraindicate ganciclovir treatment in infants.
- Additionally, there is no evidence-based research about which infants would or would not benefit from ganciclovir therapy, except that it is recommended for infants with symptomatic congenital CMV that have CNS involvement.
- Until there is more evidence to support the use of ganciclovir therapy to delay progression of SNHL in children with symptomatic congenital CMV, the risks may outweigh the benefits of treatment in the majority of

infants, except for the infants that are most severely affected by CNS involvement and that have a severe to profound SNHL (Kimberlin et al., 2003; and Michaels et al., 2003).

Educational Outcome

- Madden et al. (2005) examined the relationship between audiological outcome, educational placements and communication modes used by children with symptomatic congenital CMV.
- The children were followed longitudinally and were an average age of 12 years (range 3.4-17.1 years) at last follow-up.
- In this study, 24% used oral communication,
 - 43% used total communication, and
 - 33% used manual communication.
 - Using non-oral communication was significantly correlated with the presence of mental retardation.
- Educational placements were as follows:
 - 19% were in a mainstream educational setting,
 - 24% were at a school for the deaf,
 - 9% were in a classroom for children with hearing impairments,
 - and 48% were in a special education classroom.
 - All of the children in the mainstream setting used oral communication. Of the children that used oral communication,
 - 60% had a unilateral hearing loss,

- the other 40% had a mild to moderate bilateral hearing loss at the last follow-up.
 - Two of the children that used oral communication had both mental retardation and cerebral palsy, although the IQ/DQ and severity of cerebral palsy for each child were not described.
 - Children with symptomatic congenital CMV that had CNS involvement (including microcephaly, cerebral palsy, or mental retardation) or a profound SNHL were significantly more likely to be enrolled in special education.
 - These results suggest that communication mode is dependent on both audiological and cognitive outcomes, whereas the educational placement is more dependent on the cognitive outcome than the audiological outcome (with the exception of profound SNHL) (Madden et al., 2005).
- Schildroth (1994) also found that neurological deficits and cognitive delay were more predictive of educational outcome than audiological characteristics using data from the CADS survey. As previously mentioned, this survey is given primarily to special education programs and schools for the deaf; it is important to note that these results primarily describe children with a severe to profound SNHL.
 - The CADS survey compared the performance on the Stanford Achievement Test (for children ages 8-17) of children with

symptomatic congenital CMV to their peers in the above mentioned educational settings that did not have CMV.

- Compared to peers with hearing impairment that did not have CMV, children with symptomatic congenital CMV performed significantly worse.
- When combining the data for all children (CMV and non-CMV groups) that completed the test in this study,
 - 44% of the children with symptomatic congenital CMV performed in the lowest quartile and
 - 31% performed in the second quartile on the reading test.
 - For the mathematics computation test,
 - 54% performed in the lowest quartile and
 - 24% performed in the second quartile.
 - Since these results were normed with peers that also had severe to profound hearing impairment, this suggests that the neurological and cognitive deficits associated with symptomatic congenital CMV are more responsible for educational outcomes than audiological characteristics.
- While the majority of children in the Madden et al. (2005) study and all children in the Schildroth (1994) study were older than six years old at the last follow-up, these results have many implications for parental counseling and early intervention for the birth to six age group.

- First of all, the importance of early intervention can be emphasized using this information.
 - For example, if the child has a mild to moderate bilateral SNHL or a unilateral SNHL but normal intelligence, the parents should expect that the child will be able to use oral communication with proper aural rehabilitation therapy.
 - When the child is first diagnosed with SNHL, the parents will need to consider what type(s) of communication that they want their child to use.
 - Having information about which types of communication have been most successful for other children with symptomatic congenital CMV that have a similar audiological and cognitive profile may aid the parents in making a decision about communication.
- Also, parents are likely to ask what they can expect as their child gets older, such as educational placement and outcomes, and these results can be used to provide them with realistic expectations.
- If the child does not have any cognitive or neurological deficits, it can be a major relief to parents to know that research has shown that

audiological outcome has not been related to educational outcome.

- Conversely, if the child has a cognitive or neurological deficit, these results stress the importance of early intervention in all areas that address the child's specific needs. The parents can be counseled about the importance of a multidisciplinary team containing professionals that collectively address all of the child's needs (such as physical therapy for a motor deficit and an early interventionist for speech, language, and auditory skill development).

Asymptomatic CMV

Medical Characteristics of Asymptomatic CMV

- Of the infants who tested positive for congenital CMV in the Dollard et al. (2007) meta-analysis of universal screening studies,
- 87.3% were asymptomatic at birth.
 - Of these infants, 13.5% later developed permanent sequelae. The prevalence of children with one or more sequelae in the studies analyzed by Dollard et al. (2007) ranged from 0-23.5% with most studies reporting 8.5-17.9%. Children with asymptomatic

congenital CMV may develop the same sequelae and resulting cognitive, motor, visual, or auditory impairments as children with symptomatic congenital CMV. However, the sequelae are typically less severe in children with asymptomatic congenital CMV than children with symptomatic congenital CMV; 67.6% of the children with asymptomatic congenital CMV with SNHL had SNHL without any other CMV-related sequelae.

- These data are thought to be an underestimate because of lack of follow-up past a certain age and lack of data on visual impairment. The lack of prevalence data of various sequelae in children with asymptomatic congenital CMV is most likely due to difficulty diagnosing these children. Congenital CMV needs to be diagnosed within a few days after birth, otherwise it is indistinguishable from acquired CMV. Since children with asymptomatic congenital CMV do not present with any sequelae at birth, by the time they develop SNHL, it is impossible to diagnose them with asymptomatic congenital CMV unless there are remaining neonatal samples of dried blood that can be retrospectively analyzed (Barbi et al., 2002).

Asymptomatic CMV and SNHL

- The same characteristics of SNHL found in children with symptomatic congenital CMV are found in children with asymptomatic congenital CMV.

- However, children with asymptomatic congenital CMV overall have a less severe presentation of SNHL than children with symptomatic congenital CMV.
- The overall prevalence of SNHL in children with asymptomatic congenital CMV (7.2-25%) is significantly less than for children with symptomatic congenital CMV (30-57.8%).
- SNHL can be present in children with asymptomatic congenital CMV at birth (7.2-13.6%) or have a delayed-onset (11-18.2%); the median age for delayed onset was 27 months (range 25-62 months) (Fowler & Boppana, 2006; Fowler, McCollister, Dahle, Boppana, Britt, & Pass, 1997; Iwasaki, Yamashita, Maeda, Misawa, & Mineta, 2007; Saigal et al., 1982; and Williamson, Demmler, Percy, & Catlin, 1992).
- When considering prevalence data for children with asymptomatic congenital CMV, it is important to consider that about 1/3 of children with SNHL have no known etiology. It is highly possible that the etiology of SNHL in a number of these children is asymptomatic congenital CMV. Due to the difficulty in diagnosing asymptomatic congenital CMV (as discussed in the medical characteristics section above), the etiology of SNHL cannot be attributed to asymptomatic congenital CMV unless the child was diagnosed at birth or dried neonatal blood samples are available (Barbi et al., 2003; and Williamson et al., 1992).

- Barbi et al. (2003) explored how many children with SNHL of an unknown etiology may actually have asymptomatic congenital CMV by examining the Guthrie cards (containing dried neonatal blood) of 130 children with a SNHL >40 dBHL (click ABR thresholds) of unknown etiology to determine whether congenital CMV was present at birth.
 - Ten percent of infants that had SNHL at birth and
 - 34.2% of children that had a late-onset SNHL tested positive for CMV on their Guthrie cards.
 - Of the children that had a late-onset SNHL that was >70 dBHL, 42.7% tested positive for CMV.
 - These results suggest that asymptomatic CMV plays a much wider role in SNHL than previously thought, especially for children with severe or profound SNHL.
- Fowler & Boppana (2006) examined whether the development of specific sequelae could predict SNHL in children with asymptomatic congenital CMV and found no predictive risk factors.
 - The authors also examined the viral burden (defined as the concentration of CMV virus in urine and peripheral blood samples at infancy) of children with asymptomatic congenital CMV.
 - Children with SNHL had significantly higher viral burden levels compared to children normal hearing.

- These results suggest that children with a higher viral burden may be at an increased risk of developing SNHL; however, this needs to be further explored in future studies.
- Unilateral SNHL (75-87.5%) is more common than bilateral SNHL (12.5-25%) in children with asymptomatic congenital CMV (Iwasaki et al., 2007; and Williamson et al., 1992).
 - In both unilateral and bilateral cases, SNHL can be progressive or fluctuating.
 - Progressive SNHL is more common in children with unilateral SNHL (72.7-80%) than bilateral SNHL (20-27.3%); the median age of the first progression was 18 months (range 2-70 months);
 - fluctuating SNHL is slightly more common in children with unilateral SNHL (27.3%) than children with bilateral SNHL (18.2%).
 - Children with unilateral progressive SNHL could progress to either a unilateral or bilateral SNHL, most of the children with unilateral SNHL still had a unilateral SNHL after progression (75%).
 - Once hearing has stabilized after progression, thresholds were severe or profound in 100% of the cases reported (Fowler et al., 1997; and Williamson et al., 1992).
 - Additionally, Iwasaki et al. (2007) and Saigal et al. (1982) have reported cases of children with asymptomatic congenital CMV whose SNHL improved over time (by at least 10 dB for at least

one pure tone threshold); results included improvement from a mild unilateral SNHL to normal hearing, a profound unilateral SNHL to a mild unilateral SNHL, and a profound bilateral SNHL to normal hearing.

- The authors offer no explanation for why these children may have had improvements in hearing.
- Fowler et al. (1997) was the only study to report the prevalence of SNHL severities for unilateral and bilateral SNHL in children with asymptomatic congenital CMV.
 - Data from 307 children were analyzed in this study. It is important to note that all of the Fowler studies cited in this paper used children that were identified with congenital CMV through universal newborn screening; therefore, the prevalence data is more likely to be representative of the general population.
 - For the children with unilateral SNHL, the following prevalence of hearing loss severity were observed:
 - mild loss (9%),
 - moderate loss (9%),
 - severe loss (36.4%),
 - profound loss (17.2%), and
 - high frequency loss (affecting all or a portion of 4-12 kHz) (18.2%).

- The children with bilateral SNHL were more severely affected as a group; the following prevalence was observed:
 - moderate loss (9%),
 - profound loss (45.4%), and
 - high frequency loss (45.4%).
- Children with asymptomatic congenital CMV had a much lower prevalence of profound SNHL than children with symptomatic congenital CMV (68.7-100%) (Fowler & Boppana, 2006; Madden et al., 2005; Pass et al., 1980; and Schildroth, 1994).
- It is also interesting to note that a large percentage of children with asymptomatic congenital CMV have high-frequency SNHL compared to no children with symptomatic congenital CMV. Prevalence and type of audiometric configurations found in children with asymptomatic congenital CMV were not reported.

Neurodevelopmental and Cognitive Outcome

- Several studies examining the cognitive outcome of children with asymptomatic congenital CMV have shown that they have normal intelligence and do not significantly differ from their peers without CMV.
- Three studies compared the Stanford-Binet scores of children ranging from 3-5 years with asymptomatic congenital CMV to a matched control group;

- there was no significant difference in mean scores between groups (Saigal, Lunyk, Larke, & Chernesky, 1982; and Eichhorn, 1982). (Eichhorn reviewed studies by Reynolds et al., 1974 and Kumar, Nankervis, & Gold, 1973).
- In the Saigal et al. (1982) study,
 - 17% of the children with asymptomatic congenital CMV had SNHL, while all children in the control group had normal hearing.
 - One child (out of 47) with asymptomatic congenital CMV later developed neurological sequelae, including cerebral palsy, mental retardation, and a profound unilateral SNHL; this child was not included in this analysis of cognitive outcome because he was not able to complete the Stanford-Binet test.
 - The remaining children with asymptomatic congenital CMV with SNHL were included in the comparison of Stanford-Binet scores, and there was no significant difference between the children with asymptomatic congenital CMV and the control group. No significant correlation between IQ/DQ scores and the presence of SNHL was found.
 - However, none of these studies followed the children beyond the age of four.
 - Eichhorn (1982) suggests that it is possible that later differences may develop, and that future research should follow these children for a longer period of time.

- Ivarsson, Lernmark, & Svanberg (1997) longitudinally followed children with asymptomatic congenital CMV for ten years that did not develop any neurological symptoms by 12 months to determine the neurodevelopmental and cognitive outcome.
 - The authors excluded children that had developed SNHL by 12 months because they considered this a neurological impairment; therefore, the results of this study may not be applicable to children with asymptomatic congenital CMV that develop SNHL before one year of age.
 - The Weschler Intelligence Scale for Children (WISC) was used to examine overall intellectual development, the Griffiths' Developmental Scale assessed preschool development, and the Stott test and Circle and Maze test assessed gross and fine motor development.
 - The performance of children with asymptomatic congenital CMV that did not have any neurological symptoms on the intelligence and neurological assessments did not differ significantly from the control group over the ten year period.
 - The authors did not mention how many children with asymptomatic congenital CMV developed SNHL in this study.
 - These results indicate that if children with asymptomatic congenital CMV have normal development at 12 months, they are unlikely to

acquire developmental and intellectual deficits later in childhood (excluding SNHL).

- The findings by Ivarsson et al. (1997) can be a helpful counseling tool for parents if their child does not have any sequelae at 12 months (and no SNHL); information that the risk of developing cognitive and motor impairments is very low can be a major relief for parents. Future research should examine children with asymptomatic congenital CMV with SNHL and no neurological impairments at 12 months to determine whether these results can be replicated with that population.

Audiological management

- As discussed in the audiological management section for children with symptomatic congenital CMV, behavioral testing should be appropriate for the child's developmental age and modified if the child has any motor, visual, or cognitive deficits.
- Since a significant number of children with asymptomatic congenital CMV develop late-onset (11-18.2%) or progressive SNHL (20-80%, depending on whether the SNHL is bilateral or unilateral), regular audiological evaluations are critical so that changes in hearing status can be closely monitored and amplification/aural rehabilitation can be altered as changes occur.

- Late-onset SNHL was reported to occur between 25-62 months and progressive SNHL occurred between 2-70 months (Fowler & Boppana, 2006; Fowler et al., 1997; Iwasaki et al., 2007; Saigal et al., 1982; and Williamson et al., 1992).
- Based on these findings, regular audiological evaluations (every six months to a year) should occur for children with asymptomatic congenital CMV through at least six years of age.
- Since many of these studies did not follow children past the age of six and progressive SNHL has been reported up to at least ten years old in children with symptomatic congenital CMV, extending the audiological follow-up through at least the age of ten may be advisable.
- It is currently not possible to predict which children with asymptomatic congenital CMV will develop SNHL based on sequelae (Fowler & Boppana, 2006).
- Therefore, every child that has been diagnosed with asymptomatic congenital CMV should receive regular audiological evaluations to watch for the development of SNHL. As discussed earlier, the majority of children with asymptomatic congenital CMV will not be diagnosed because most babies are not screened for CMV at birth.
- However, for children in hospitals that do universal screening for CMV, parents should be counseled about the importance of regular audiological

follow-up so that if their child develops a SNHL, early detection can minimize the impact to language and auditory skill development by starting amplification and aural rehabilitation therapy as soon as possible.

- Additionally, since so many children with SNHL have no known etiology (about 1/3), these children should have audiologic management as if it were caused by asymptomatic congenital CMV, regardless of initial severity (regular audiological assessments to monitor whether progressive SNHL occurs) (Williamson et al., 1992 and Barbi et al., 2002).

Amplification outcomes

- Amplification use in children with asymptomatic congenital CMV was only mentioned in two studies.
- Saigal et al. (1982) was the only study that examined hearing aid usage; all children with asymptomatic congenital CMV in this study with a profound SNHL (unilateral or bilateral) used hearing aids and were enrolled in special education.
- These children were not significantly different from their normal hearing peers on intelligence measures and did not have any neurological sequelae, so the enrollment in special education was attributed to the profound SNHL.
- However, the amplification outcome in children with asymptomatic congenital CMV with a profound SNHL is likely to be very different

today than it was for the Saigal et al. (1982) study, since cochlear implants are also an option for a profound SNHL.

- Additionally, the number of children identified through early detection is much improved today because of universal newborn hearing screening. Consequently, the child's speech, language, and auditory skill development outcomes are improved because timely aural rehabilitation therapy can be given in response to early detection.

- In the Iwasaki et al. (2007) study, two children with progressive SNHL received a cochlear implant.
 - One child started with hearing aids and had an improvement in speech development until 24 months of age, when speech development stopped and the hearing loss progressed further. He received a cochlear implant at 39 months.
 - The other case was a female who had normal hearing that progressed to a profound bilateral SNHL. At 24 months, she had a delay in speech development and she received a cochlear implant at 29 months. Neither case mentions whether the child received a unilateral or bilateral implant or the speech and language outcomes after implantation. Their cases demonstrate the importance of regular follow-up and evaluation of speech, language and auditory skill development in children with asymptomatic congenital CMV. In both cases, when the SNHL further progressed and/or a speech

delay appeared, the child received a cochlear implant shortly after, which would minimize the impact of the delay.

- As discussed in the section on amplification outcomes for children with symptomatic congenital CMV (pg 11-14), cochlear implant outcomes in children that have CMV-related deafness have been examined (Lee et al., 2005 and Inscoe & Nikolopoulos, 2004).
 - However, the authors did not specify which children were symptomatic or asymptomatic when reporting the outcomes.
 - Speech, language, and auditory skill development outcomes for children with asymptomatic congenital CMV should be expected to be the same as discussed for the children with symptomatic congenital CMV after considering neurological and cognitive characteristics, i.e., children with congenital CMV (asymptomatic or symptomatic) that have the same severity of cognitive delay should be expected to achieve the same outcomes with a cochlear implant.

Educational Outcomes

- Saigal et al. (1982) assessed educational performance using the Wide Range Achievement Test (WRAT).
 - The WRAT assesses preschool performance in reading, spelling, and mathematics; results indicated similar performance between children with asymptomatic congenital CMV and the control group.

- Eichhorn's (1982) review found that failure in a mainstream school setting was predicted by an IQ <90, profound SNHL, and hyperactivity in children with asymptomatic congenital CMV and a control group matched for hearing loss characteristics and IQ/DQ scores.
 - Based on these factors, 36% of the children with asymptomatic congenital CMV were predicted to have problems in a mainstream school setting
 - compared to 14% of children from the matched control group. Since Eichhorn's (1982) paper was a review of several studies which I could not get full-text for, it is unknown what age these children were at assessment or how many of them had each risk factor or combination of risk factors.
 - Based on Saigal et al.'s (1982) finding that children with asymptomatic congenital CMV had preschool performance that matched their peers without CMV, it is likely that the failure in a mainstream school setting occurs sometime after preschool.
- Since children with asymptomatic congenital CMV do not differ significantly in intelligence compared to their peers without CMV, parents should expect the same educational outcomes whether their child has asymptomatic congenital

CMV or does not have CMV. If the child develops SNHL, parents should have the same expectations of the child as they would for a child with normal hearing, as long as early detection and proper amplification and aural rehabilitation therapy occur.

- There are several possibilities for why children with asymptomatic congenital CMV may have worse school performance as they get older even though they match their peers in preschool.
 - First of all, the development of learning disabilities or other sequelae may occur past the age of preschool (Eichhorn, 1982).
 - Secondly, progressive or late-onset SNHL can occur past preschool age. Even though this information is about the outcome for children past the age of six, it can be useful for counseling parents during the birth to six period about educational outcomes.
- This information can be used to emphasize the importance of regular audiological evaluations to detect progressive or late-onset SNHL, and also the importance of closely monitoring the child's educational progress. If progressive or late-onset SNHL is caught early, the impact on language and auditory skill development and

resulting educational performance can be minimized. If a learning disability develops at a later age, close monitoring of the child's academic performance should improve the chances of early detection and minimize problems with academics because the child can receive proper services.

Behavioral Outcomes

- Saigal et al. (1982) also examined whether there were any differences in behavioral outcomes for children with asymptomatic congenital CMV compared to a matched control group from birth through five years of age.
- Developmentally appropriate stimulation in the home was measured using the Caldwell Inventory of Home Stimulation.
- Additionally, the Eyberg and Connors inventory of behavioral ratings were given at five years.
- There was no significant difference between children with asymptomatic congenital CMV and the matched control group for the overall scores for home stimulation.
- However, scores were significantly lower in the children with asymptomatic congenital CMV for avoidance of restriction and punishment and organization of the physical and temporal environment (younger than 3 years), and for stimulation through toys, games, and reading materials (older than 3 years).

- Scores were significantly higher for children with asymptomatic congenital CMV for parental modeling and encouraging of social maturity.
- Additionally, the children with asymptomatic congenital CMV had significantly more behavioral problems, as shown by the Eyberg and Connors test.
- The greater behavioral problems in children with asymptomatic congenital CMV could be linked to the avoidance of restriction and punishment for these children.
- Hearing loss has been linked to behavioral problems in children due to frustration from communication problems. However, comparison of behavioral problems in children with asymptomatic congenital CMV with and without SNHL revealed no significant difference, suggesting that hearing loss is not a factor in the development of behavioral problems in the children in this study (Saigal et al., 1982).
- It was also interesting that the children over three years old with asymptomatic congenital CMV had less stimulation through toys, games, and reading materials than their peers without CMV, even though they did not differ in cognitive or motor development (with the exception of one child), and only 17% of them had SNHL.
- While behavioral outcome has not been examined in children with symptomatic congenital CMV, having less stimulation compared to peers without CMV would be more expected because parents may be more

likely to treat them differently due to the sequelae and resulting disabilities. Further research should examine whether these results can be replicated in children with asymptomatic congenital CMV, and if so, what factors may be responsible for the difference in behavioral outcome.

- Since the asymptomatic congenital CMV group should be expected to have the same outcomes as their peers without CMV (if no cognitive delays are present), parents should be counseled to have the same expectations for their child and accordingly provide the same home stimulation as they would for a child without asymptomatic congenital CMV.

Symptomatic and Asymptomatic CMV

- Since children with symptomatic or asymptomatic congenital CMV can have the same medical and SNHL characteristics at the same range of severity, considerations regarding newborn hearing screening (NHS) and aural rehabilitation therapy depend on the sequelae and SNHL characteristics for each individual child with congenital CMV, not whether the congenital CMV is symptomatic or asymptomatic.
- Therefore, NHS and aural rehabilitation issues will be considered for all children with congenital CMV, and differentiation between symptomatic and asymptomatic congenital CMV will be made when necessary.

NHS and CMV-Related SNHL

- Universal NHS has immensely improved early detection of hearing loss in babies. However, there is concern that many children with congenital CMV with SNHL will be missed using NHS.
- First of all, the children that are born with a mild SNHL that is not severe enough to meet fail criteria will be passed and the parents may not know that the child should have audiological follow-up to monitor for development of progressive SNHL.
- The Joint Committee on Infant Hearing set fail criteria as a ≥ 30 dB hearing loss. Since hearing loss in children is considered to be ≥ 20 dBHL, some children with congenital SNHL will not be detected by NHS (Fowler, Dahle, Boppana, & Pass, 1999).
- Secondly, previous studies have demonstrated that a number of infants will develop late-onset SNHL (30-33% of symptomatic and 11-18.2% of asymptomatic) (Fowler & Boppana, 2006; Kylat et al., 2006; Rivera et al., 2002; Fowler et al., 1997; Iwasaki et al., 2007; Saigal et al., 1982; and Williamson et al., 1992). These infants have normal hearing at birth and would therefore be missed by NHS.
- Fowler et al. (1999) longitudinally followed 388 children from birth through six years with congenital CMV (symptomatic and asymptomatic) that received NHS to determine the efficacy of NHS in identifying SNHL in children with congenital CMV. NHS detected SNHL in 5.2% of all children with congenital CMV at birth.

- At the last follow-up (72 months), 15.4% of the children with congenital CMV had SNHL. Based on these results, NHS only detected less than half of all of the children with congenital CMV that developed SNHL during the first six years of life. The authors did not distinguish whether the children had symptomatic or asymptomatic congenital CMV when reporting this data, but clearly both groups had children that would have been missed by NHS.
- Since children with symptomatic congenital CMV are diagnosed at birth because they have one or more sequelae at birth, these children should hopefully be closely followed audiotologically because CMV-related SNHL has been well-documented.
- Parents should be counseled about the importance of regular audiological evaluations for the first several years of life (as discussed on pg. 9-10). Additionally, they should be encouraged to receive a complete audiological evaluation within the first couple months of life, even if their child passed the screening, since the child could have a SNHL between 20-30 dBHL.
- Parents should be counseled that while their child passed the NHS, if they have a SNHL between 20-30 dBHL, it will be detrimental to speech, language, and auditory skill development.
- The implications of having SNHL missed by NHS may be greater for children with asymptomatic congenital CMV.

- Since these children do not have any sequelae at birth, there is no reason to suspect that the child has congenital CMV, unless he/she is diagnosed at birth by universal CMV screening.
- As discussed earlier, the majority of infants do not receive universal CMV screening, therefore, children with asymptomatic congenital CMV that pass the NHS but have a 20-30 dB SNHL or will develop late-onset SNHL are at risk of late detection.
- Since there is no reason to suspect asymptomatic congenital CMV, parents will not be counseled to seek further audiological follow-up if their child passes the NHS.
- Therefore, the child's SNHL may go unnoticed until it progresses to a more severe level, or a significant speech or language delay appears.

Should all babies be screened for CMV at birth?

- A significant number of children diagnosed with asymptomatic congenital CMV by universal screening for CMV will develop SNHL (7.2-25%),
 - many will have late-onset (11-18.2%) or
 - progressive SNHL (20-27.3% bilateral and
 - 72.7-80% unilateral).
 - Additionally, Barbi et al. (2003) found that asymptomatic congenital CMV is responsible for a large percentage (34.2%) of

SNHL of unknown etiology through retrospective testing of Guthrie cards.

- As previously discussed, congenital CMV can only be diagnosed within a few days of birth, because otherwise it is impossible to distinguish congenital CMV from acquired CMV. Testing all babies through universal screening for CMV would identify all asymptomatic cases, which would allow for regular audiological evaluations and watching for development of sequelae and associated disabilities.
- Universal screening for CMV would not be any more invasive than other newborn screening tests, since Guthrie cards, urine samples, or buccal swabs could be used. However, universal screening would add extra expense.
- Additionally, since the majority of infants with asymptomatic congenital CMV do not develop permanent sequelae (86.5%), diagnosis of asymptomatic congenital CMV could needlessly worry many parents.
- Until a more cost-effective method for universal screening and stronger predictive risk factors for developing permanent sequelae and SNHL in children with asymptomatic congenital CMV are discovered, universal screening of infants for CMV may be unfeasible.

- While research has not examined this, testing all children that fail the first NHS for CMV may be a method for detecting more children with asymptomatic congenital CMV. However, many children with asymptomatic congenital CMV will still be undiagnosed, since many will develop a late-onset SNHL or have a congenital SNHL between 20-30 dBHL and therefore pass the NHS.

Aural Rehabilitation and Language Outcome

- Since many children with congenital CMV (particularly symptomatic) have cognitive, motor, and/or visual deficits in addition to SNHL, aural rehabilitation therapy should be adjusted to meet the needs of each individual child, using play that is developmentally appropriate for the child.
- The early interventionist should consider any motor, neurological, or visual deficits that may affect the child's performance on the FAPI and adjust the FAPI accordingly so that an accurate portrayal of the child's auditory skill development can be obtained prior to beginning aural rehabilitation therapy.
- The early interventionist that is providing aural rehabilitation therapy should maintain regular communication with the diagnostic audiologist regarding the child's progress.
- The early interventionist should be aware that children with congenital CMV often have progressive SNHL (including

unilateral to bilateral), and be observant of whether the child exhibits any changes in hearing ability.

- As soon as the child exhibits difficulty hearing certain sounds or phonemes that he/she could previously hear, the early interventionist should refer the child back to the diagnostic audiologist for a follow-up audiological evaluation to determine whether progression of SNHL has occurred and so that the child's amplification can be adjusted accordingly.
- Additionally, when considering which type of communication mode to use with their child, parents should be counseled about considering flexibility with communication modes as hearing loss progresses, especially if the child is at risk of developing progressive SNHL that will become severe to profound.
- Parents may wish to consider having the child simultaneously learn oral communication and sign language, so that if the child's hearing loss progresses to a point where the child is not getting enough language from oral communication, sign language can provide benefit and minimize the impact on language development, especially since progressive SNHL typically occurs over the first five years of life, which is an important time in language development (Madden et al., 2005; Rivera et al., 2002).
- Aural rehabilitation therapy will vary widely for children with congenital CMV depending on the characteristics of the SNHL. A

child that is born deaf will require more training in auditory skill development than a child that has a late-onset or progressive SNHL that later became deaf, since the children with late-onset or progressive SNHL will have had some auditory access prior to becoming deaf which aided in their auditory skill development.

- The timing of the late-onset SNHL is important to consider, because the children's auditory, language and speech skills prior to aural rehabilitation therapy depend on how much time they have had normal hearing.
- The later the onset of SNHL occurs, the more access children have had to (oral) language and the greater chance they have had for speech development, since they can hear other people talking and also hear themselves producing various speech sounds. Children with a unilateral SNHL have more access to language than children with a bilateral SNHL, since they have one normal ear, so the later the onset of progressive SNHL occurs, the better auditory access to language the child has had.
- Parents should be counseled about how children with one normal ear are still at risk of developing delays which can lead to failure in school (35% in the Bess, Klee, & Culbertson (1986) study) and should be closely monitored.
- Children with normal intelligence should be expected to develop normal language, and children with a cognitive delay should be

expected to have the amount of language appropriate for their developmental age, regardless of the severity of SNHL, provided that early detection occurs and proper aural rehabilitation therapy is given. This is useful for parent counseling to provide them with realistic expectations for their child.

- Often, parents may expect less of their child if he/she has a motor or neurological deficit, even if the child has normal intelligence, due to physical appearance. The parents should be taught how to interact with the child in a way that maximizes auditory skill development using the child's strengths.

Conclusion

- While research has greatly expanded our knowledge of the effects of congenital CMV on young children ages birth through six, there are still many questions remaining to be answered.
- There is currently much information about medical characteristics and associated outcomes.
- Additionally, the characteristics of SNHL have been closely examined (time of onset, severity, progression, and fluctuation) and a few associated outcomes, including amplification usage, cognitive outcome, and educational placements.
- However, there is still much to learn about the effects of CMV-related SNHL. Most of the studies examined in this paper focused

on children that had a severe or profound SNHL or severe sequelae (especially for the children with symptomatic congenital CMV).

- Outcomes for children with congenital CMV that have milder presentation of sequelae and a mild or moderate SNHL should be examined. Additionally, the outcome in children that progress from a unilateral to bilateral SNHL has not been extensively studied.
- Further research also needs to be conducted about outcomes associated with amplification and communication modes. The research about amplification outcomes is mainly focused on the children with severe to profound SNHL. Research should further examine the outcome of auditory skill, speech, and language development based on hearing aid and/or FM usage in children with CMV-related SNHL with greater representation of the children that have a mild to moderate SNHL. Use of various communication modes and educational outcome was only studied in Madden et al. (2005) for children with symptomatic congenital CMV with SNHL. Other than the Saigal et al. (1982) study of children with asymptomatic congenital CMV, social and emotional outcomes have not been examined.
- The largest topic related to congenital CMV and SNHL that needs more research is the outcomes directly related to aural rehabilitation (speech, language, and auditory skill development).

Other than data from the cochlear implant studies (Lee et al., 2005 and Inscoe & Nikolopoulos, 2004), there is no data about speech and language outcomes for children with congenital CMV and SNHL. The outcome of specific areas of language development (phonology, morphology, syntax, semantics, and pragmatics) have not been examined in children with CMV-related SNHL.

- Additionally, development of play in children with congenital CMV has not been studied. Filling in these research gaps will help with treatment of children with congenital CMV-related SNHL in many areas, including early intervention, amplification, aural rehabilitation therapy, and providing parents with more evidence-based expectations.

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